

Dual Carrier Preparations for Viking

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Multiple spacecraft vehicles for the Viking mission require simultaneous transmission of two S-band carriers from a single Deep Space Station. Past experience in high-power diplexing, coupled with dual carriers, has shown that, in addition to controlled uplink intermodulation products, a complex form of receive band interference will be generated within the ground station. Recent efforts to define and minimize these effects are being supplemented with additional resources including reconfiguration of DSS 13 for dual-carrier diplexed operation with the objective of assuring DSN capability in the Viking mode.

I. Introduction

Two simultaneous uplinks and four simultaneous downlinks are to be supported by each Deep Space Station (DSS) of the 64-m-diameter antenna subnet for the Viking 1975 mission to Mars (Ref. 1). A 26-m-diameter antenna subnet will also be utilized during certain mission phases including cruise periods during which the two spacecraft will not lie within a single antenna beam. This 26-m-diameter support will be in the customary single uplink and one or two downlink configuration.

During orbital operations, two additional vehicles (landers) will be in time-shared communications with the DSN, utilizing a common S-band carrier frequency allocation. Three other S-band channels provide for each orbiter and for a spare orbiter radio system. The fourth downlink is at X-band, coherently generated from one of the orbiter S-band uplinks in the so-called S/X band mode.

Early work on dual uplinks from a single DSS includes field investigations in relation to the Apollo Manned

Space Flight Network (MSFN) (Refs. 2 and 3) and preparations for Mariner Mars 1971 (Ref. 4).

II. Interference Problems

Experience has shown that wherever multiple carriers share a common high-intensity field, mixing or inter-modulation products (IMPs) can be expected to be generated (Refs. 2, 3, and 5). As a practical matter, this interaction can and will occur in some degree both within the internal waveguide system (Ref. 6) and in the external incidental nonlinearities encountered in the illuminated portion of the antenna structure as well as in the near field physical environment of the station (Ref. 5). This latter point illustrates the fact that even two independent, but adjacent, stations cannot be presumed to be totally free of this effect.

Within the context of the DSN, these IMPs will, in general, appear within the uplink transmit band and as a self-jamming of the receiving band, regardless of where they may be generated in a given configuration. Whether or not they degrade performance depends, of course, on the frequency and amplitude distribution in either link for the configuration in question.

Another effect, in the DSN context known as "noise bursts," has been encountered in single-carrier diplexed operation in a variety of circumstances (Refs. 7-10). While this is a continuing concern, an intensive program at DSS 14 of waveguide maintenance and the reduction and control of "loose" incidental hardware in the illuminated portion of the antenna has resulted in some improvement of the single high-power carrier performance (Ref. 11). This phenomenon is primarily manifested as an impulse-like random increase in the receiving system temperature. In severe form, it has been known to momentarily disrupt receiver tracking and presumably to degrade the data streams. More work is needed in this area to correlate data quality to observed system temperature, but, as yet, there is no known verified report of loss of operational data quality attributable to noise bursts.

Of particular concern in the dual uplink mode is the evidence that the noise burst phenomenon is greatly intensified under this condition as well as apparently interacting with, and probably contributing to, the IMP effect (Ref. 2).¹

¹Also evidenced in many observations and system temperature recordings taken in the course of recent dual carrier testing at DSS 14.

III. Status for Viking

The current S-band frequency allocations for the Viking mission (channels 9, 13, 16, 20) (Ref. 12) have been selected to preclude uplink IMPs falling "on channel" in addition to the usual single-carrier criteria (Ref. 1). One additional consideration was applied to minimize the level of high order IMPs in the receive band: reduction of channel separation has the effect of drawing higher order (and consequently weaker amplitude) products into the receiving band, some 180 MHz removed from the transmitting band.

Current overall performance at DSS 14 for nominal 40-kW dual carriers provides a minimum carrier-to-adjacent-channel IMP ratio of 20 dB in the uplink and receiving band interference in the form of quasi-monochromatic IMPs ranging from the order of -160 dBmW to a presumed -190 or -200 dBmW level depending upon which pair of the four uplink S-band channels are in use at given time. At this time, it is known that the receiving band IMP has a time-varying (in the spectral range of 1 Hz) amplitude and or phase modulation component and probably has a typical spectral width of more than 10 Hz. Whether or not the similar spectral characteristics of the noise burst phenomenon are causal or coincidental has not yet been determined. In addition to the IMPs, dramatic increases in apparent broadband noise occur (as monitored by the maser instrumentation equipment, including system temperature) and are seemingly time correlated to the instantaneous IMP level.

In addition to the maser instrumentation equipment, the principal instrumentation in use has included conventional spectrum analyzers and the standard DSN phase-locked receiver. Recent attempts at calibration of the amplitudes of the weaker IMPs and of their spectral characteristics by means of digital processing techniques have offered some qualitative confirmation of these phenomena. Further work in this area is expected to provide quantitative data which can be applied to the question of possible degradation of tracking in the presence of this interference.

These conclusions have been developed for Viking over the last two or three years and are based primarily upon the DSS 14 dual-exciter, single 400-kW klystron configuration (Ref. 1). Noise burst investigations have also been conducted at the Goldstone Microwave Test Facility (MTF), and 100-kW klystron uplink data have been obtained in the dual 10-kW mode at DSS 13 (Ref. 13).

Documentation of the DSS 14 work is largely in the form of informal memoranda for the period of late 1969 to date. Alternative methods of dual carrier generation have been considered, notably time sharing (Refs. 14-16), but do not at this time appear promising for the Viking application.

Because two-thirds of the 64-m-diameter antenna sub-net is scheduled to be equipped with 100-kW klystrons and because scheduling adequate time at DSS 14 to pursue these concerns of dual carrier interference is

virtually impossible, an effort has been recently undertaken to reconfigure DSS 13 for 100-kW single/dual carrier diplexed test operation (Ref. 13).

This facility, together with continued intermittent usage of DSS 14, will provide the opportunity to quantitatively bound the interference phenomena, to hopefully reduce and control them through microwave and antenna modifications, and, if necessary, to provide the basis of negotiation of operational solutions to the residual interference.

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